Extracorporeal Membrane Oxygenation as an Alternative to Ventilation

Essay

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Rofayda Yaser Elsayed

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List of Abbreviations

ALI : Acute lung injury

ARDS : Adult respiratory distress syndrome

BIPAP : Biphasic positive airways pressure

CESAR : Conventional Ventilation or ECMO for Severe Adult Respiratory Failure

ECMO : Extracorporeal membrane oxygenation

ELSO : Extracorporeal Life Support Organization

FIO_2 : Fraction of inspired oxygen

HFOV : High-frequency oscillatory ventilation

ICU : Intensive care unit

INO : Inhaled nitric oxide

LV : Left ventricle

MAP : Mean airway pressure

$mSvO_2$: Mixed venous oxygen saturation

OI : Oxygenation index

PA : Pulmonary artery

PaO_2 : Oxygen tension (partial pressures) of arterial blood

PEEP : Peak end expiratory pressure

PIP : Peak inspiratory pressure

PMP : Polymethylpentene

PPHN : Persistent pulmonary hypertension of the newborn

PVR : Pulmonary vascular resistance

RA : Right atrium

List of Abbreviations *(Cont.)*

RCT : Randomized controlled trial

RPM : Revolutions per minute

RR : Respiratory rate

VA : Veno-arterial

VAV : Veno-arterial-venous

VI : Ventilation Index

VILI : Ventilator-induced lung injury

VV : Veno-venous

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Introduction

Extracorporeal membrane oxygenation (ECMO) is an adaptation of conventional cardiopulmonary bypass techniques to provide cardiopulmonary support. ECMO provides physiologic cardiopulmonary support to aid reversible aspects of the disease process and to allow recovery. ECMO does not provide treatment of the underlying disease. The indications for ECMO support have expanded from acute respiratory failure to acute cardiac failure refractory to conventional treatments from wide patient subsets involving neonates to adults ***(Chauhan and Subin, 2011).***

In May 1953, Gibbon used artificial oxygenation and perfusion support for the first successful open heart operation. In 1954, Lillehei developed the cross-circulation technique by using slightly anesthetized adult volunteers as live cardiopulmonary bypass apparatuses during the repair of certain congenital cardiac disorders (***Lowry et al., 2013).***

In 1955, at the Mayo Clinic, Kirklin improved on Gibbon's device and successfully repaired an atrial septal defect ***(Wolfson, 2003).***

In 1965, Rashkind and coworkers were the first to use a bubble oxygenator as support in a neonate dying of respiratory failure ***(Bartlett and Esperanza, 1985).***

In 1969, Dorson and colleagues reported the use of a membrane oxygenator for cardiopulmonary bypass in infants ***(Alpard et al., 2002).***

In 1970, Baffes et al reported the successful use of extracorporeal membrane oxygenation as support in infants with congenital heart defects who were undergoing cardiac surgery. In 1975, Bartlett were the first to successfully use ECMO in neonates with severe respiratory distress ***(Peek and Sanowski, 1997).***

Since its introduction, ECMO has become a mainstay in the management of neonatal and pediatric patients with refractory respiratory and/or cardiac failure secondary to a wide range of diagnoses, including meconium aspiration, pulmonary hypertension, pneumonia, myocarditis, cardiomyopathy, sepsis, and ARDS ***(Turner and Cheifetz, 2013).***

Currently, results imply that ECMO is superior to conventional ventilation providing lung rest. There is expansion in the indications for ECMO including a bridge to lung transplantation, the use of ECMO in awake patients, liver

transplantation, as well as in adult respiratory distress syndrome ***(Malagon and Donna Greenhalgh, 2013).***

There is limited understanding of the long-term impact of ECMO on quality of life and long-term cognitive and physical functioning for many groups, especially the cardiac and pediatric populations. This deserves further study ***(Mehta and Laura, 2013).***

Aim of the Work

This work aims to review the current medical literature about extracorporeal membrane oxygenation (ECMO), its application in neonates and adults as an alternative for ventilation, its indications contraindications, technical details and complications.

Chapter (1)
Extracorporeal Membrane Oxygenation

Extracorporeal membrane oxygenation (ECMO) is a modified adaptation of conventional cardiopulmonary bypass techniques for prolonged cardiopulmonary support using intrathoracic or extrathoracic cannulation. ECMO is currently used at specialized centers to support patients with respiratory or cardiac failure who are unresponsive to conventional therapeutic interventions ***(Butt and Maclaren, 2013).***

ECMO Circuit Design:

A standard ECMO circuit consists of Fig (1):

1- Mechanical blood pump,
2- Gas exchange device (membrane oxygenator),
3- Heat exchanger,
4- Circuit tubing:all components of ECMO connected together with circuit tubing between the venous access cannula and either the arterial (VA) or venous (VV) infusion cannula
5- Monitors

(McMullan et al., 2011).

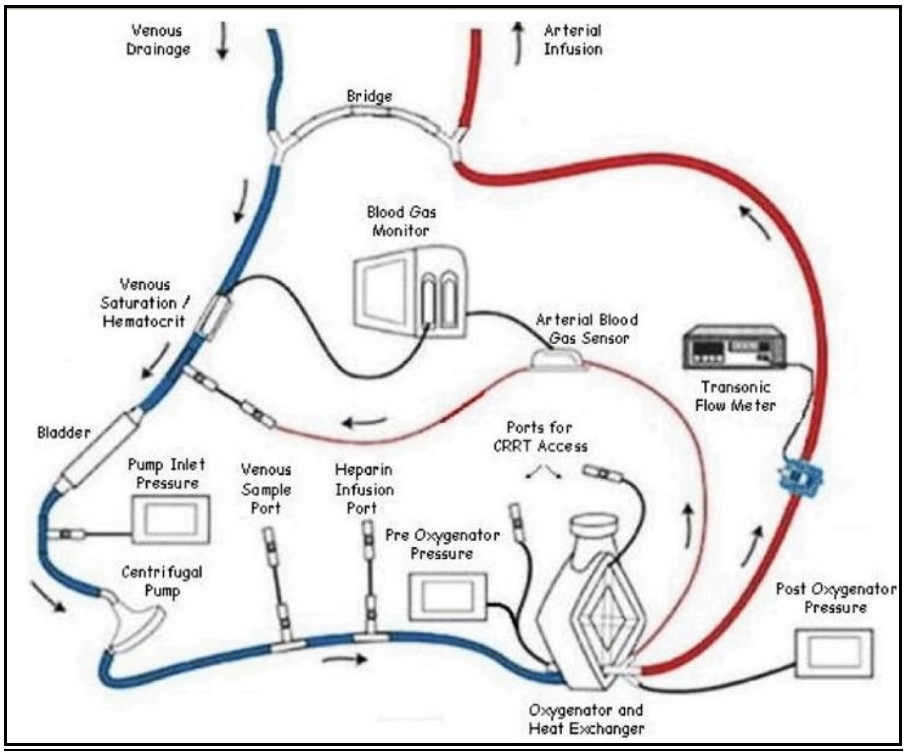

Figure (1): ECMO circuit ***(McMullan et al., 2011).***

Figure (2): A traditional extracorporeal membrane oxygenation system ***(Turner and Cheifetz, 2013).***

1- Pumps:

A pump is an essential component of the ECMO circuit, there are two types of pumps roller pumps and centrifugal pumps.

a-Roller pumps:

Semiocclusive roller pumps have been the standard for decades, but have mainly been replaced by novel centrifugal pumps ***(Walfson et al, 2003).***

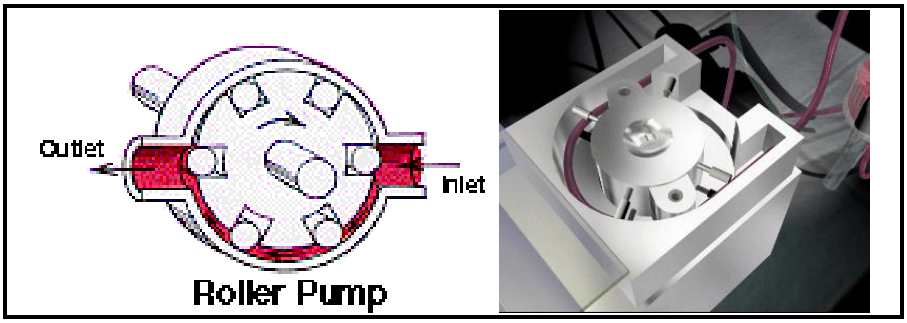

Figure (3): Roller Pump ***(Walfson et al, 2003).***

Problem with roller pumps:

They could generate direct suction on the venous catheter. In practice, this problem is avoided by the inclusion of a small collapsible bladder positioned at the lowest point of the venous line. The bladder (or a transducer directly in the venous line) is attached to an electrical switch that slows or stops the roller pump when a threshold suction is reached, then restarts the pump instantly when the filling pressure exceeds the pump suction (i.e., the venous drainage flow exceeds the pump flow). The suction on the venous cannula